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EE 1001
- Introduction to Control Systems -

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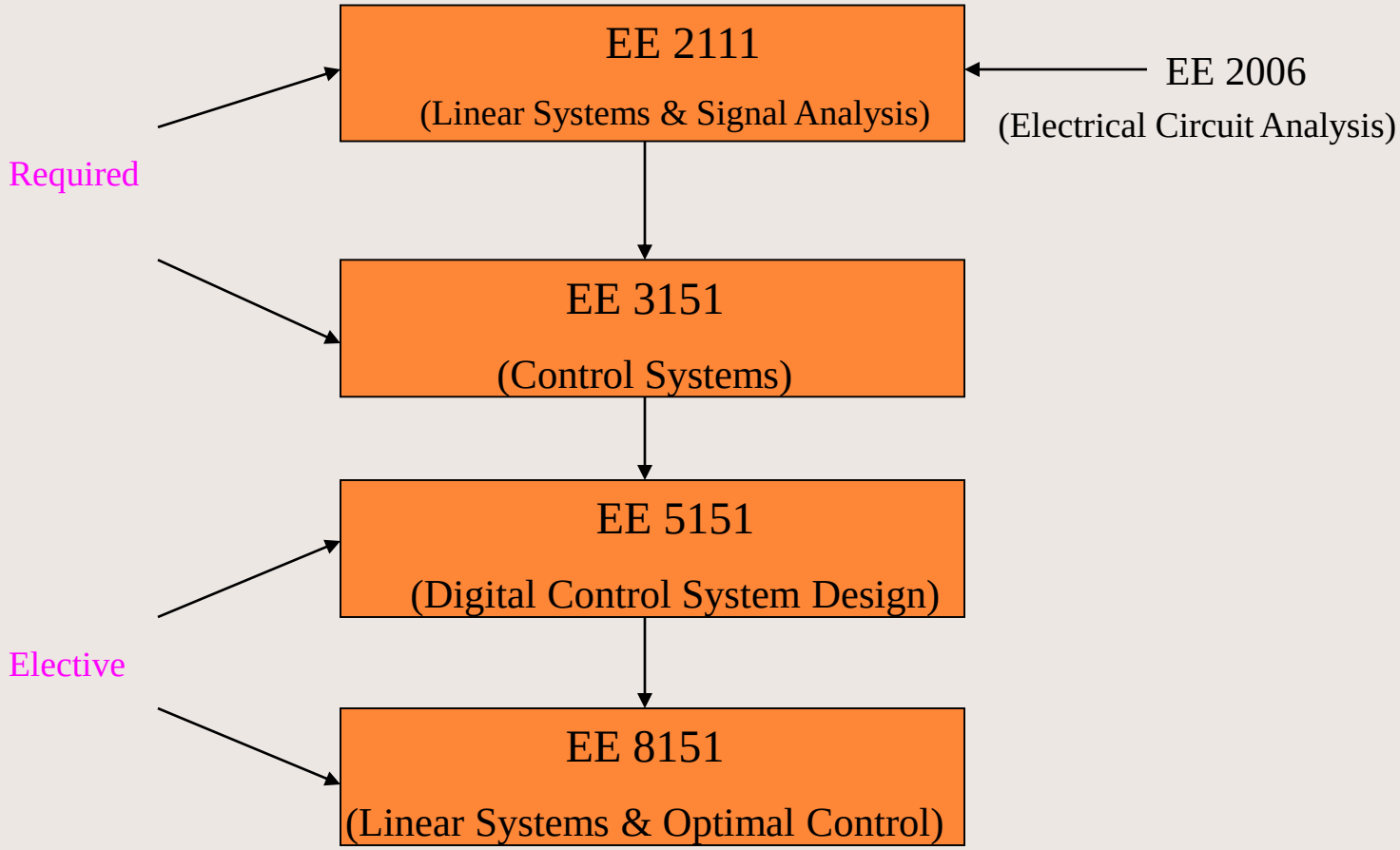
Outline

- Systems & Control Courses
- Introduction to Control Systems
  - Examples of Control System Applications
  - What is a Control System?
  - Basic Control System Components
  - Open-Loop vs. Closed
- Software (Matlab, Simulink, Toolboxes)

Systems & Control Courses



"Why do you need a control system at all?"

- What good is an oven if you can't control the temperature? What good is an airplane if a pilot can't make it go where he wants it to go? …….
- The common denominator in these questions is that there is some physical quantity that must be somehow controlled in a desirable way.

⇨ Need to think about how to control physical quantities, and to determine what can be done to implement the way we want.

Examples of Control Applications

Control is everywhere. Aircraft and spacecraft, process plants and factories, homes and buildings, automobiles and trains, cellular telephones and networks … these and other complex systems are testament to the ubiquity of control technology.

- Aircraft autopilot
- Disk drive read-write head positioning system
- Robot arm control system
- Automobile cruise control system

etc.

The Impact of Control Technology – Overview, Success Stories, and Research Challenges - A special report published by the IEEE Control Systems Society at http://ieeecss.org/general/impact-control-technology

What is a Control System?

A control system is an interconnection of components forming a system configuration to provide a desired system response.

NASA Dryden Flight Research Center Photo Collection
http://www.dfrc.nasa.gov/gallery/photo/index.html
NASA Photo: EC91-491-6 Date: September 13, 1991

X-29 at High Angle of Attack

Basic Control System Components

- Plant (or Process)

  - The portion of the system to be controlled -

Actuator

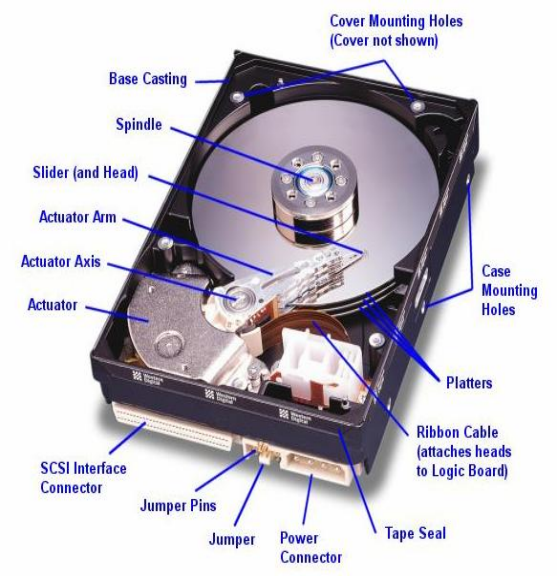
An actuator is a device that provides the motive power to the process (i.e., a device that causes the process to provide the output).

Sensor

A sensor most likely has an output, typically a voltage, that is proportional to the physical variable it measures.

Controller

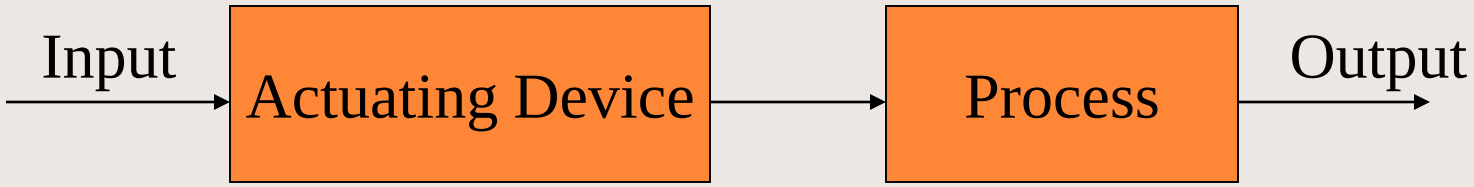
A controller is a device, possibly in the form of a chip, analogue electronics, or computer, which monitors and physically alters the operating conditions of a given dynamical system.



Control engineering is fundamentally about the integration of many elements – plant, sensors, actuators, computing platform, algorithm

§ Open-Loop Control Systems

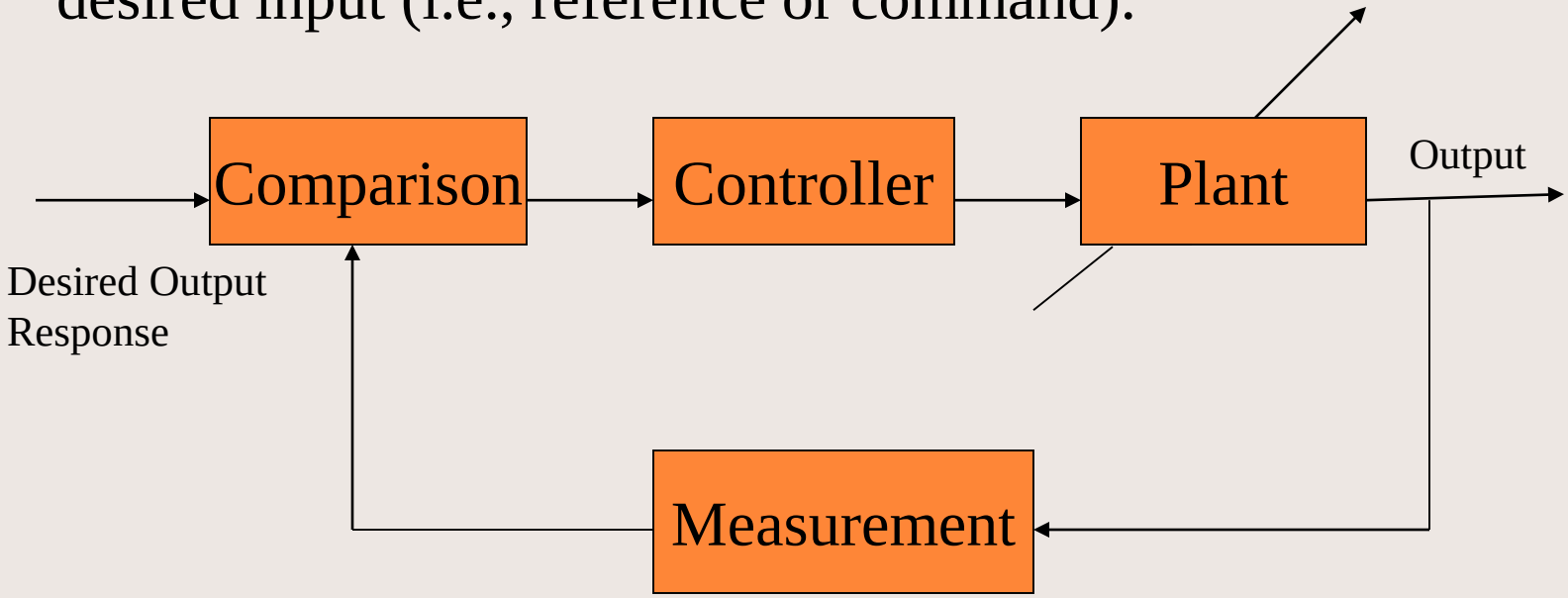
An open-loop control system utilizes an actuating device to control the process directly without using feedback.



The system outputs have no effect upon the signals entering the process. That is, the control inputs are not influenced by the process outputs.

§ Closed Loop (Feedback) Control Systems

A closed-loop control system uses a measurement of the output and feedback of this signal to compare it with the desired input (i.e., reference or command).



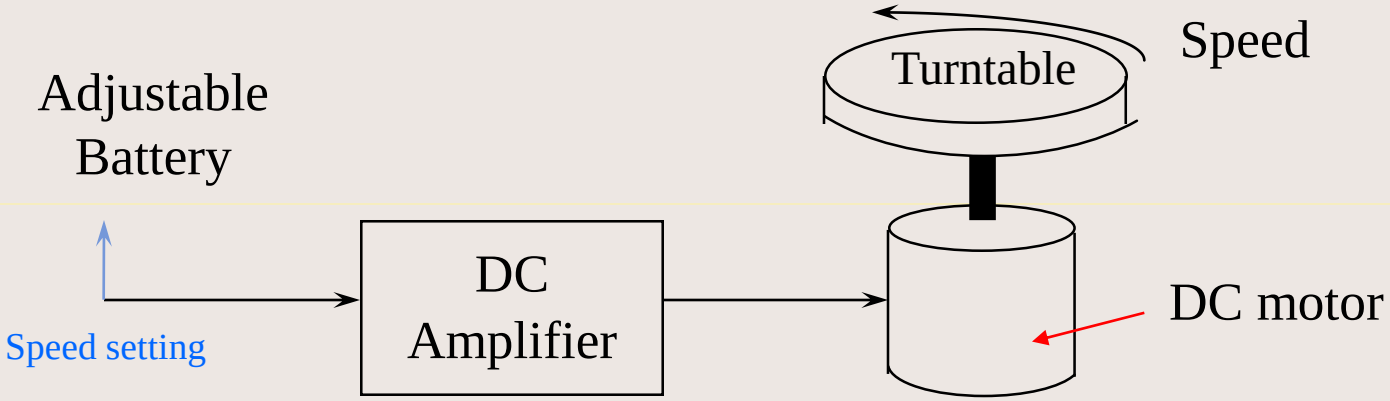
Closed-loop: General Form

Example (Ref: Dorf and Bishop, *Modern Control Systems*, 12/e, Prentice Hall, 2011)

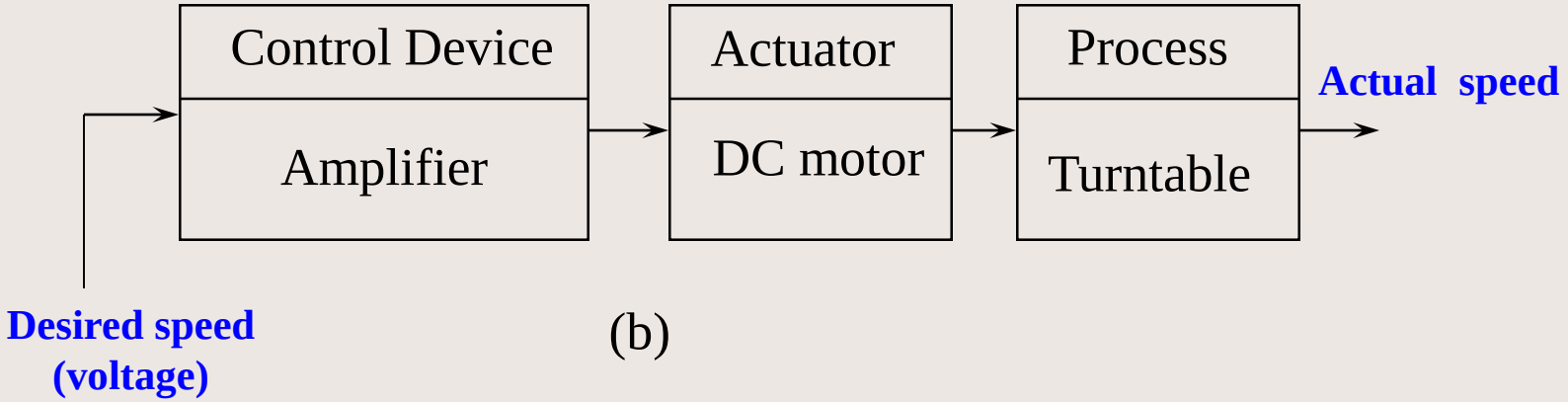
Turntable Speed Control (Open-loop vs. Closed-loop)

- Many modern devices use a turntable to rotate a disk at a constant speed. For example, a computer disk drive and a CD player all require a constant speed of rotation in spite of motor wear and variation and other component changes.

- For the turntable speed control, the goal is to design a controller that will ensure that the actual speed of rotation is within a specified percentage of the desired speed despite all possible uncertainties.

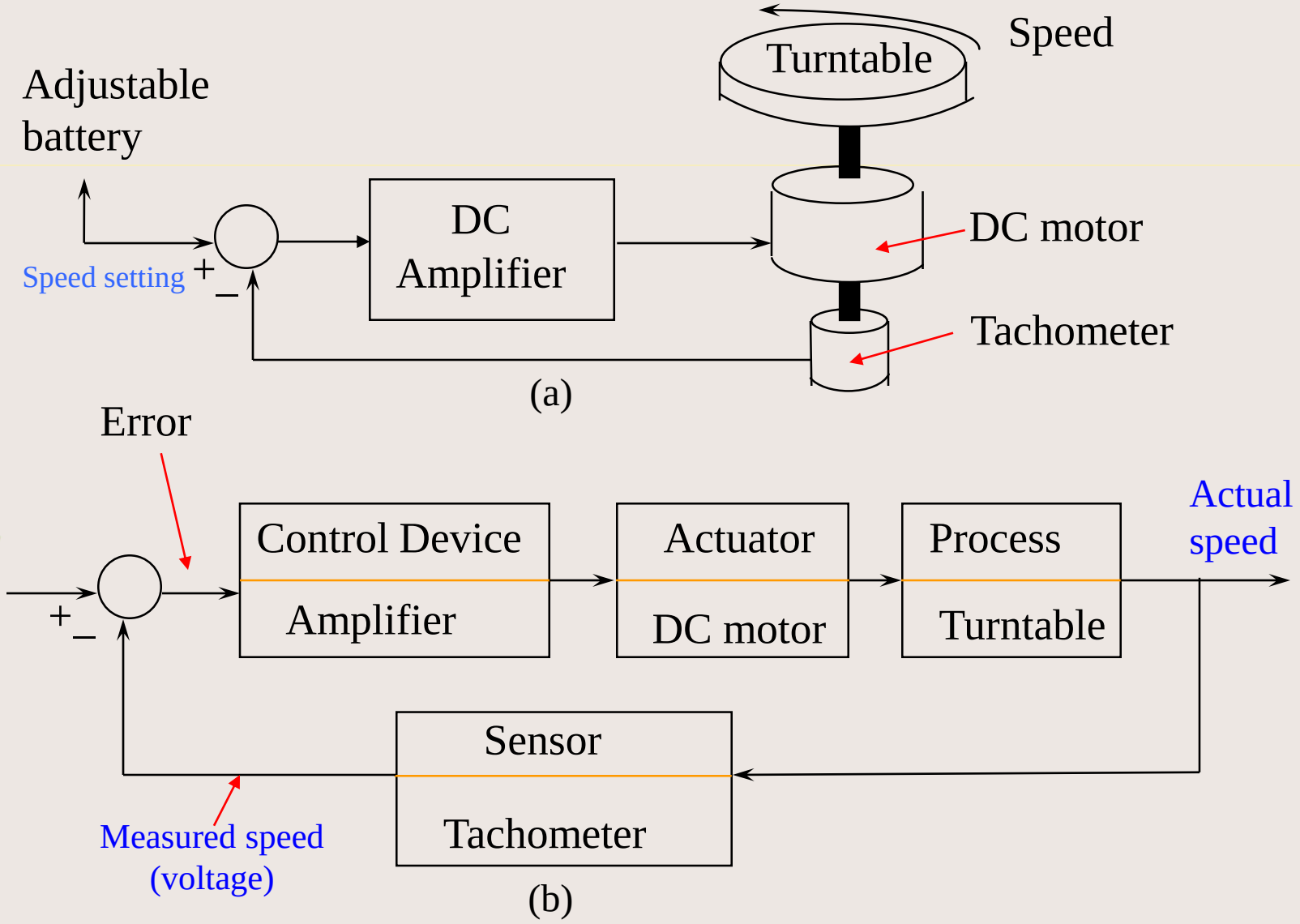


(a)



(b)

Turntable speed control: open-loop



Turntable speed control: closed-loop

Motivations for Feedback

The main reasons of using feedback are the following:

- Reducing the sensitivity of the performance to parameter variations of the plant and imperfections of the plant model used for design
- Reducing the effects of external disturbances and sensor noises

Feedback can also

- Improve transient response characteristics
- Reduce steady-state error

MATLAB (**MAT**rix **LAB**oratory)

- Matlab is a software package developed by Mathworks for high performance numerical computation and visualization. It has been widely adopted in the academic community.
- Many universities and colleges around the world use MathWorks products for teaching and research in a broad range of technical disciplines
- Matlab provides an interactive environment with hundreds of built-in functions for technical computation, graphics, and animation.
- Matlab also provides easy extensibility with its own high level programming language.

http://www.mathworks.com/products/matlab/

Toolboxes

- Toolboxes are libraries of Matlab functions that customize Matlab for solving particular classes of problems.
- Toolboxes are open and extensible; you can view algorithms and add your own.
- Toolboxes: control systems, communications, signal processing, robust control, neural network, image processing, optimization, wavelet, system identification, etc.

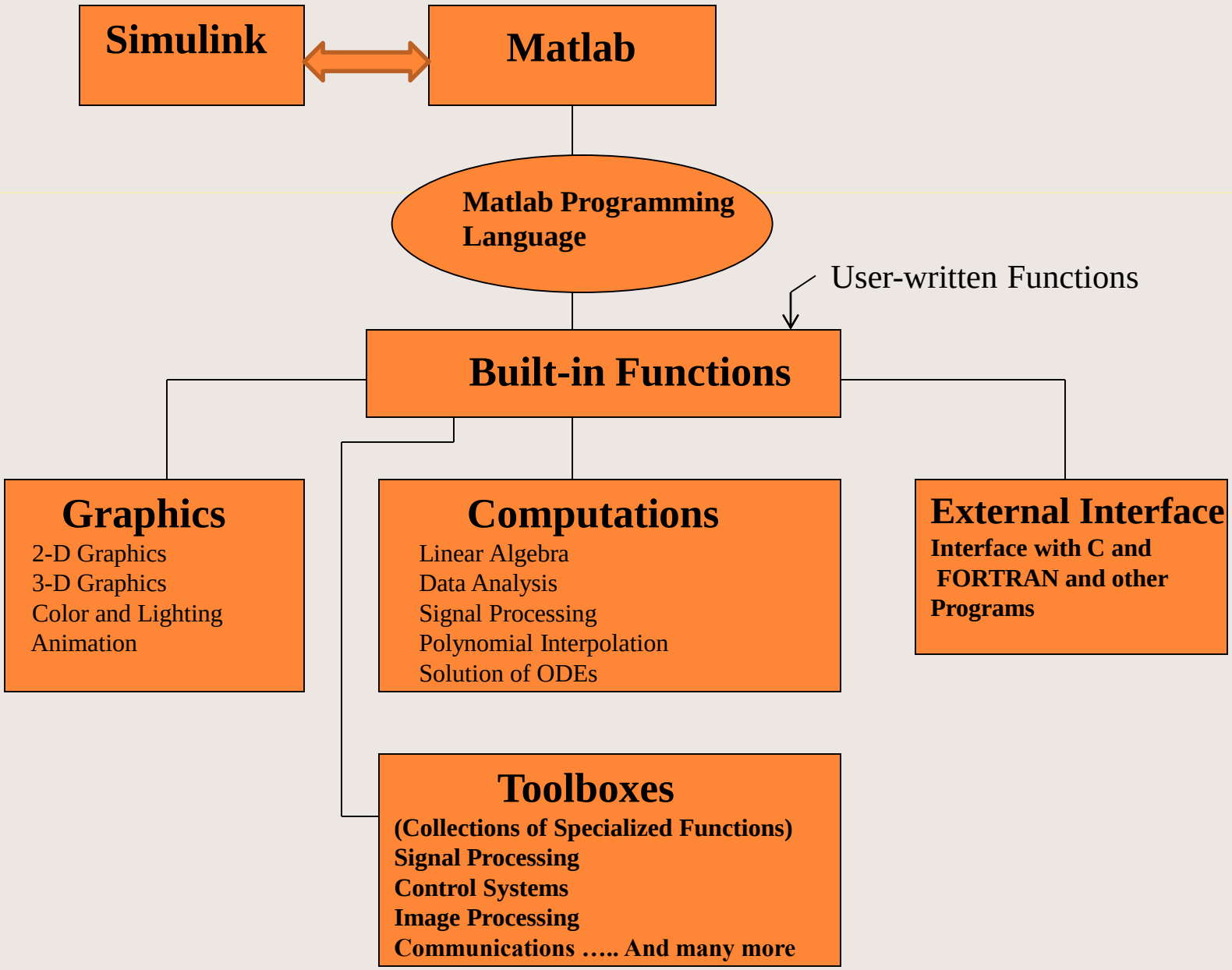
SIMULINK

- Simulink is an extension to Matlab that allows engineers to rapidly and accurately build computer models of dynamical systems, using block diagram notation.

- Simulink is a software package for use with Matlab for modeling, simulating, and analyzing dynamical systems. Its graphical modeling environment uses familiar block diagrams, so systems illustrated in text can be easily implemented in Simulink.

- The simulation is interactive, so you can change parameters and immediately see what happens. It supports linear and nonlinear systems, modeled in continuous time, sampled time, or a hybrid of the two.

http://www.mathworks.com/products/simulink/


Simulink
Matlab
Matlab Programming Language
User-written Functions
Built-in Functions
Graphics
2-D Graphics
3-D Graphics
Color and Lighting
Animation
Computations
Linear Algebra
Data Analysis
Signal Processing
Polynomial Interpolation
Solution of ODEs
External Interface
Interface with C and FORTRAN and other Programs
Toolboxes
(Collections of Specialized Functions)
Signal Processing
Control Systems
Image Processing
Communications ….. And many more

Matlab and Control Systems Tutorials

- Matlab and Simulink Tutorials are available in

http://www.mathworks.com/academia/student_center/tutorials

- Interactive Control Systems Tutorial

http://www.mathworks.com/academia/student_center/tutorials/controls-tutorial.html